IS 2150 / TEL 2810
Introduction to Security

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Lecture 3

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Access Control Model
Foundational Results

Protection System

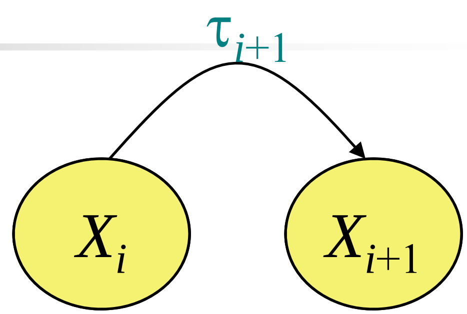
- State of a system
  - Current values of
    - memory locations, registers, secondary storage, etc.
    - other system components
- Protection state (P)
  - A system state that is considered secure
- A protection system
  - Captures the conditions for state transition
  - Consists of two parts:
    - A set of generic rights
    - A set of commands

Protection System

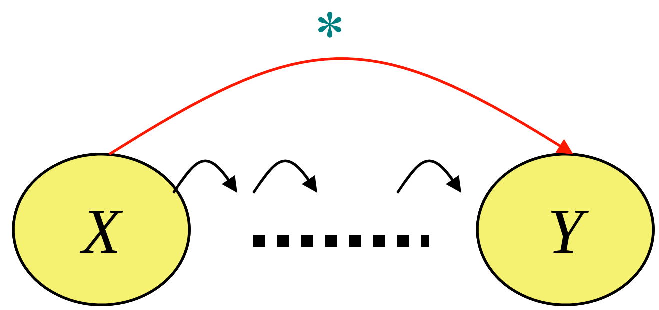
- Subject (S: set of all subjects)
  - Eg.: users, processes, agents, etc.
- Object (O: set of all objects)
  - Eg.:Processes, files, devices
- Right (R: set of all rights)
  - An action/operation that a subject is allowed/disallowed on objects
  - Access Matrix A: $a[s, o] \subseteq R$
- Set of Protection States: (S, O, A)
  - Initial state $X_0 = (S_0, O_0, A_0)$

State Transitions

$X_i \vdash_{\tau_{i+1}} X_{i+1}$: upon transition τ_{i+1}, the system moves from state X_i to X_{i+1}

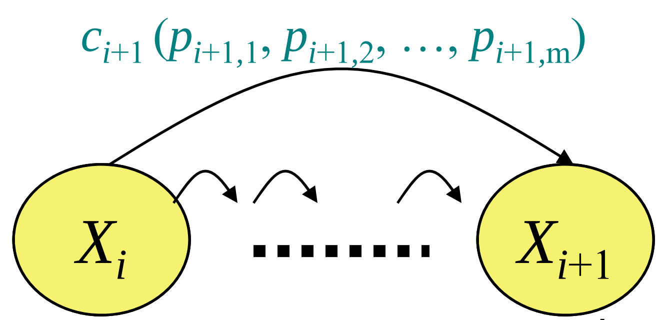


$X \vdash^* Y$: the system moves from state X to Y after a set of transitions



$X_i \vdash c_{i+1}\,(p_{i+1,1}, p_{i+1,2}, \ldots, p_{i+1,m})\; X_{i+1}$:
state transition upon a command

For every command there is a sequence of state transition operations



Primitive commands (HRU)

Create subject s	Creates new row, column in ACM; s does not exist prior to this
Create object o	Creates new column in ACM o does not exist prior to this
Enter r into $a[s, o]$	Adds r right for subject s over object o Ineffective if r is already there
Delete r from $a[s, o]$	Removes r right from subject s over object o
Destroy subject s	Deletes row, column from ACM;
Destroy object o	Deletes column from ACM

Primitive commands (HRU)

Create subject *s*

Creates new row, column in ACM;
s does not exist prior to this

Precondition: $s \notin S$

Postconditions:

$S' = S \cup \{ s \}$, $O' = O \cup \{ s \}$

$(\forall y \in O')[a'[s, y] = \varnothing]$ (row entries for s)

$(\forall x \in S')[a'[x, s] = \varnothing]$ (column entries for s)

$(\forall x \in S)(\forall y \in O)[a'[x, y] = a[x, y]]$

Primitive commands (HRU)

Enter r into $a[s, o]$

Adds r right for subject s over object o

Ineffective if r is already there

Precondition: $s \in S$, $o \in O$

Postconditions:

$S' = S$, $O' = O$

$a'[s, o] = a[s, o] \cup \{ r \}$

$(\forall x \in S')(\forall y \in O')$

$[(x, y) \neq (s, o) \rightarrow a'[x, y] = a[x, y]]$

System commands

- [Unix] process p creates file f with owner *read* and *write* (r, w) will be represented by the following:

Command $create\_file(p, f)$

Create object f

Enter own into $a[p,f]$

Enter r into $a[p,f]$

Enter w into $a[p,f]$

End

System commands

- Process p creates a new process q

Command $spawn\_process(p,\ q)$

Create subject q;

Enter own into $a[p,q]$

Enter r into $a[p,q]$

Enter w into $a[p,q]$

Enter r into $a[q,p]$

Enter w into $a[q,p]$

End

Parent and child can signal each other

System commands

- Defined commands can be used to update ACM

  Command $make\_owner(p, f)$

  Enter own into $a[p,f]$

  End

- Mono-operational:
  - the command invokes only one primitive

Conditional Commands

- Mono-operational + mono-conditional

  Command *grant_read_file*(*p, f, q*)

  If *own* in *a*[*p,f*]

  Then

  Enter *r* into *a*[*q,f*]

  End

Conditional Commands

- Mono-operational + biconditional

Command *grant_read_file*(*p, f, q*)

If *r* in *a*[*p,f*] and *c* in *a*[*p,f*]

Then

Enter *r* into *a*[*q,f*]

End

- Why not “OR”??

Fundamental questions

- How can we determine that a system is secure?
  - Need to define what we mean by a system being “secure”
- Is there a generic algorithm that allows us to determine whether a computer system is secure?

What is a secure system?

- A simple definition
  - A secure system doesn't allow violations of a security policy
- Alternative view: based on distribution of rights
  - Leakage of rights: (unsafe with respect to right r)
    - Assume that *A* representing a secure state does not contain a right *r* in an element of A.
    - A right *r* is said to be leaked, if a sequence of operations/commands adds *r* to an element of *A*, which did not contain *r*

What is a secure system?

- Safety of a system with initial protection state X_o
  - Safe with respect to r: System is *safe with respect to r* if *r* can never be leaked

  - Else it is called unsafe with respect to right *r*.